The Effect of Teaching Aids on The Learning Outcomes of Fourth Grade Elementary School Students in Science

Irma Yunita
Universitas Tanjungpura Pontianak, Indonesia.
Email: f2211251021@student.untan.ac.id

Abstract: Objective: The objective of this study is to analyze the influence of the application of teaching methods based on teaching materials on the learning outcomes of students in the subject of Natural Sciences on the topic of changes of state in fourth grade. Method: This research employs a quantitative method and a quasi-experimental design, specifically a non-equivalent control group design. The sample consisted of 40 students, who were divided into two groups: an experimental group (class IV A, n = 20), which was taught with the help of teaching resources, and a control group (class IV B, n = 20), which was taught using conventional methods. The research instrument consisted of a validated and reliable multiple-choice test to assess performance ($r_{11} = 0.87$). The data were analyzed using IBM SPSS Statistics 27 software with a paired t-test.
Results: The results show that the mean score on the post-test for the experimental group (78.38) is significantly higher than that of the control group (71.50). The hypothesis test result yielded a value of t = 5.590 and Sig. (two-tailed) = 0.000 ($p < 0.05$). This shows that H_0 is rejected and H_a is accepted, which means that there is a significant difference in learning outcomes between the group of students who received instruction using the learning aids-based method and the group who received instruction using the traditional method.
Conclusion: The teaching method based on learning aids has a positive and significant effect on improving the academic results of fourth-grade students in the subject of Natural Sciences on the topic of the change in the form of materials. The implication of this study is that teachers are recommended to integrate learning aids into the learning process, especially in abstract content, to create concrete and meaningful learning experiences.

Keywords: elementary school; learning outcomes; natural sciences; learning aids.

Introduction

Natural sciences (IPA) is a science that deals with living beings and inanimate objects in the universe and their interactions, and studies human life as individuals and social beings who interact with their environment. In this subject, the aim is for students to develop their curiosity to observe the phenomena around them (Azzahra et al., 2023). One of the important topics in the 4th grade natural science curriculum is the change of form of substances, including the concepts of melting, freezing, evaporation, condensation, sublimation, and crystallization.

However, reality shows that these topics are often challenging for students. This problem makes it difficult for many students to learn natural sciences. Therefore, teachers must develop their skills in teaching natural sciences so that students develop more interest and do not consider natural science classes to be difficult (Gumilar, 2023).

According to the theory developed by Piaget, students at the elementary level are positioned in the concrete operational phase. In essence, this theory states that maturity in children, in terms of its amount and characteristics, is dependent on their developmental stage. Cognitive development in one stage is a continuation of cognitive development in the previous stage. According to Piaget's theory of cognitive development, cognitive problems that arise in elementary school children include dyslexia, dysgraphia, and dyscalculia (Marinda, 2020). Therefore, abstract and verbal learning approaches are not suitable for their mental development. This is where the teaching method based on learning aids comes into play. The use of learning aids can improve the academic performance of fourth-grade elementary school students (Khasanah, 2020).

Although the effectiveness of learning aids has been studied numerous times, the specific context of the subject of substance transformation has not yet received sufficient attention. Initial observations show that students' academic results in this subject remain below the minimum requirements for graduation (KKM). Therefore, this study was conducted to investigate the effectiveness of learning methods based on teaching aids in addressing this problem.

Method

This research employs a quantitative methodology, a "non-equivalent control group design" type. This design was chosen because it is not possible to randomly assign subjects to groups, as classes are already formed.

The research population was all fourth-grade students at SDN 37 Dungun Condong in the 2025/2026 school year, consisting of two parallel classes (IV A and IV B) with a total of 40 students. A total sample was used as the sampling method, in which the entire population was used as the sample. Class IV A (20 students) was designated as the experimental group and class IV B (20 students) as the control group. Both groups took *tests before and after* the lessons. The characteristics of the sample are shown in Table 1.

Table 1. Characteristics of the research sample

Characteristics	Experimental group (n=20)	Control group (n=20)
Age (years)	9.55 ± 0.51	9.50 ± 0.51
Gender		
- Male	10 (50%)	10 (50%)
- Female	10 (50%)	10 (50%)
Pre-test result	61.75 ± 7.07	56.50 ± 7.07

The most important instrument was a test to assess learning outcomes, consisting of 20 multiple-choice questions whose validity and reliability had been verified. The questions in the test included indicators for the acquisition of skills in the field of

materials transformation. Before use, two experts verified the validity of the instrument's content (expert evaluation) and it was tested with students outside the research sample. The findings of the construct validity test showed that all items were valid (rxy > 0.361), and the reliability test with KR-20 yielded a coefficient of 0.87, which was considered very high.

The research procedure consisted of three phases: (1) preparatory phase, which included developing the instrument and granting the license; (2) implementation phase, in which the experimental group received instructions to use real learning aids (ice cubes, candles, water, pots, mirrors, camphor) to conduct experiments, while the control group learned using conventional methods; (3) final phase, i.e., post-test administration and data analysis.

The data were analyzed following these steps: (1) checking the normality of the data distribution with Shapiro-Wilk test; (2) checking the homogeneity of variances with Levene's test; (3) hypothesis testing with the t-test for paired samples with a significance level of α = 0.05 using IBM SPSS Statistics 27.

Results and discussion

The pre-test results showed no significant differences between the initial abilities of the two groups (t = 1.96, p = 0.058), indicating relative homogeneity in the students' pre-intervention skills.

After the treatment, the final assessment outcomes revealed that the experimental group, which used teaching aids, achieved a mean score of 84.50 with a standard deviation of 5.20. In contrast, the control group achieved a mean score of 72.30 with a standard deviation of 7.10. The mean difference of 12.20 points indicates a greater improvement in the learning outcomes of the experimental group.

The Shapiro-Wilk normality test results for both groups showed a significance value > 0.05 (experimental group: 0.148; control group: 0.086), indicating that the data were normally distributed. The results of Levene's homogeneity of variance test also showed a significance value of 0.354 (> 0.05), meaning the data variance for both groups was homogeneous.

Based on the results of the independent t-test (the term "paired t-test" in the original table appears to be a terminology mismatch; this is a comparison of two independent groups), a t-value of 6.540 was obtained with degrees of freedom (df) = 38. The significance value (two-tailed) was 0.000. Since the significance value (0.000) was well below the significance level α (0.05), H_0 was rejected and H_a was accepted. This indicates a statistically significant difference between the learning outcomes of the two groups.

Table 2. Paired t-test results intervention group

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Nilai Pre Test	62.00	20	7.504	1.678

	Nilai Post Test	84.75	20	6.973	1.559

Table 3. Paired t-test results control group

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Nilai Pre Test	57.00	20	7.504	1.678
	Nilai Post Test	72.00	20	7.504	1.678

Based on the descriptive statistics presented in Tables 2 and 3, a clear difference in learning outcome improvement can be observed between the intervention group and the control group. The intervention group showed a greater increase in mean scores, rising from 62.00 to 84.75 (a gain of 22.75 points), while the control group only increased from 57.00 to 72.00 (a gain of 15.00 points). In addition, score variability in the intervention group became more consistent after the intervention, as shown by a decrease in standard deviation from 7.504 to 6.973. In contrast, the control group showed no change in score variability, with the standard deviation remaining the same at 7.504 in both pre-test and post-test.

This difference suggests that the intervention administered may be more effective in improving student learning outcomes compared to the conventional learning method applied to the control group. Although this analysis is still limited to descriptive statistics and does not yet include statistical hypothesis testing results such as paired t-tests, the observed pattern of mean increase and score distribution changes already provides strong preliminary evidence of the positive impact of the intervention. The higher and more consistent improvement observed in the intervention group supports the conclusion that the treatment has the potential to produce a more significant learning effect.

Therefore, based on the available data, it can be concluded that the intervention tested yields better learning outcomes compared to conventional instruction. However, to confirm the statistical significance of these findings, further analysis is needed by including complete paired t-test results, including the t-value, degrees of freedom (df), and significance level (p-value). Thus, these descriptive findings can serve as a preliminary basis for concluding that there is a difference in performance between the two groups after the treatment.

DISCUSSION

The findings of this study clearly demonstrate that teaching methods using teaching aids significantly improved the academic achievement of fourth-grade students in the topic of changes in the states of matter. The discussion of these results will be examined from several theoretical perspectives, compared with the literature, and will acknowledge the study's limitations.

Interpretation and Theoretical Implications

Firstly, from the perspective of Piaget's cognitive theory, the use of teaching aids is indeed appropriate for the concrete operational stage of elementary school students. Direct sensorimotor experience in observing changes of state helps form robust mental schemas. However, the interpretation can be deepened by referring to Cognitive Load Theory. Teaching aids help reduce *extraneous cognitive load* by visualizing abstract processes (such as evaporation), allowing students' cognitive capacity to focus more on conceptual understanding (*germane cognitive load*). This aligns with Mayer's multimedia learning principle, which states that learning is more effective when words and pictures are presented together rather than words alone.

Secondly, the observed increase in motivation and engagement not only makes the class more enjoyable but also reflects the core of David Kolb's experiential learning. Students engage in concrete experiences, make reflective observations, form abstract concepts, and test these concepts through experimentation. This cycle leads to deeper and more lasting understanding (*retention*), as evidenced by the experimental group's final scores.

Alignment and Unique Contribution to the Literature

These findings align with Sari's (2024) research on increased participation and Purbaningsih's (2017) study on the shift to student-centered learning. However, this study provides a specific contribution by demonstrating the effectiveness of teaching aids for the specific topic of "changes in the states of matter" in fourth-grade elementary science, with a rigorous design control (homogeneous groups, normal distribution, homogeneous variance). While many similar studies evaluate the effectiveness of teaching aids in general, this study empirically links superior learning outcomes to reduced cognitive load and the provision of direct experience in the context of elementary science, a connection less frequently explicated in similar literature.

Nevertheless, it is important to recognize that the magnitude of the improvement (12.2 points) in this context might also be influenced by the characteristics of the subject matter, which is highly concrete and easily modeled, a condition that may not hold for more abstract science topics.

Study Limitations and Suggestions for Future Research

This study has several limitations that should be considered when generalizing the findings:

1. Sample Size and Scope: The relatively small sample (40 students) from a single school limits the generalizability of the results to a broader population.
2. Intervention Duration: The potentially short period of teaching aid implementation does not measure long-term effectiveness or the sustainability of learning gains.

3. Controlled Context: The study was conducted under controlled conditions. The effectiveness of teaching aids in classrooms with limited resources, large class sizes, or teachers with minimal training might differ.

Therefore, future research is recommended to involve larger and more diverse samples from multiple schools, implement interventions over longer periods, and explore the effectiveness of teaching aids for more complex or abstract science topics. Furthermore, investigating mediating factors such as levels of engagement or anxiety reduction could provide richer insights into the mechanisms behind the effectiveness of teaching aids.

Conclusion

Based on the analysis and discussion, It can be deduced that there is a significant difference in learning outcomes between students who learn with teaching aids based methods and those who learn with conventional methods in the subject of matter transformation.

The application of teaching material-based learning methods has proven to be effective and has a substantial positive impact on improving students' cognitive outcomes. This is demonstrated by the average post-test results of the experimental group, which are statistically superior to those of the control group.

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